

CE ADRA2 problem set 21
David Kennedy Villanueva
11878779

1.) (10 pts) Determine the uniform depth y_0 , given A , and wetted perimeter P for the following conditions:

(a) Trapezoidal channel,

$$m_1 = 2.5, m_2 = 3.5, b = 4.5 \text{ m}, Q = 35 \text{ m}^3/\text{s},$$

$$n = 0.015, S_0 = 0.00035$$

Solution:

$$A = by + \frac{1}{2} y^2 (m_1 + m_2)$$

$$P = b + y (\sqrt{1+m_1^2} + \sqrt{1+m_2^2})$$

$$B = b + y (m_1 + m_2)$$

$$A = 4.5y + 3y^2$$

$$P = 4.5 + 6.3326y$$

$$\text{note that } y = y_0$$

$$R = \frac{A}{P}$$

$$R = \frac{4.5y + 3y^2}{4.5 + 6.324y}$$

$$Q = \frac{C_1}{n} A R^{2/3} \sqrt{S_0}$$

$$35 = \frac{1}{0.015} A R^{2/3} \sqrt{0.00035}$$

↓↓

$$28.0624 = A R^{2/3}$$

$$y_0 = y = 2.1509 \text{ m (4th decimal)}$$

$$A = 23.5585 \text{ m}^2$$

$$P = 18.1209 \text{ m}$$

$$y_0 = 2.15 \text{ m}$$

$$A = 23.56 \text{ m}^2$$

$$P = 18.12 \text{ m}$$

(b) Circular channel, $d = 2.1 \text{ m}$, $Q = 1.25 \text{ m}^3/\text{s}$,
 $n = 0.012$, $S_0 = 0.001$

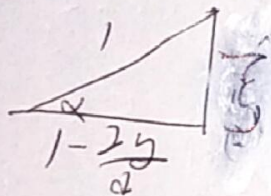
$$A = \frac{d^2}{4} (\alpha - \sin \alpha \cos \alpha)$$

$$P = \alpha d$$

$$B = d \sin \alpha$$

$$\alpha = \cos^{-1} \left(1 - \frac{2y}{d} \right)$$

$$\cos \alpha = 1 - \frac{2y}{d}$$



$$\sqrt{\left(1 - \frac{2y}{d}\right)^2 + z^2} = 1$$

$$z^2 = 1 - \left(1 - \frac{2y}{d}\right)^2$$

$$z = \sqrt{1 - \left(1 - \frac{2y}{d}\right)^2}$$

$$= \sqrt{\frac{4y}{d} - \frac{4y^2}{d^2}} \quad \sin \alpha = \sqrt{\frac{4y}{d} \left(1 - \frac{y}{d}\right)}$$

$$= \sqrt{\frac{4y}{d} \left(1 - \frac{y}{d}\right)}$$

$$Q = \frac{C_1}{n} A R^{2/3} \sqrt{S_D}$$

$$1.6128 = A R^{2/3}$$

$$A = 1.1025 (\alpha - 5 \sin \alpha \cos \alpha)$$

$$P = 2.1 \alpha$$

$$R = 0.525 \left(1 - \frac{\sin \alpha \cos \alpha}{\alpha} \right)$$

$$\alpha = \cos^{-1}(1 - 0.9524y)$$

$$\cos \alpha = 1 - 0.9524y$$

$$\sin \alpha = 1.7801 \sqrt{y(1 - 0.4562y)}$$

$$y_D = y = 1.3138 \text{ m}$$

$$A = 2.2799 \text{ m}^2$$

$$P = 3.8320 \text{ m}$$

$$b_D = 1.31 \text{ m}$$

$$A = 2.28 \text{ m}^2$$

$$P = 3.83 \text{ m}$$

1c) Circular Channel, $d = 6 \text{ ft}$, $Q = 120 \text{ ft}^3/\text{sec}$,
 $n = 0.012$, $S_0 = 0.001$

$$Q = \frac{C_1}{n} A R^{2/3} \sqrt{S_0}$$

$$\frac{Qn}{C_1 \sqrt{S_0}} = A R^{2/3}$$

$$\frac{(120)(0.012)}{1.49 \sqrt{0.001}} = A R^{2/3}$$

$$30.5616 = A R^{2/3}$$

$$y_0 = 4.1529 \text{ ft}$$

$$A = 20.8800 \text{ ft}^2$$

$$P = 11.7913 \text{ ft}$$

$$y_0 = 4.15 \text{ ft}$$

$$A = 20.88 \text{ ft}^2$$

$$P = 11.79 \text{ ft}$$

(4) Trapezoidal channel, $Q = 15 \text{ m}^3/\text{s}$,
 $n = 0.011$, $S_b = 0.0013$, "most efficient"
cross section

$$A = \left(b + \frac{y}{\tan \theta} \right) y$$

$$P = b + \frac{2y}{\sin \theta}$$

$$\theta = 60^\circ; \quad y = \frac{\sqrt{3}}{2} b$$

$$Q = \frac{C_1}{n} A R^{2/3} \sqrt{S_0}$$

$$A = b + \frac{\sqrt{3}}{4} b^2$$

$$P = b + 2b = 3b$$

$$R = \frac{1}{3} + \frac{\sqrt{3}}{12} b$$

$$\frac{Q n}{C_1 \sqrt{S_0}} = A R^{2/3}$$

$$4.5763 = A R^{2/3}$$

$$b = 2.6369 \text{ ft}$$

$$y_0 = 2.3009 \text{ ft}$$

$$A = 5.7136 \text{ ft}^2$$

$$p = 7.9707 \text{ ft}$$

$$y_0 = 2.30 \text{ m}$$

$$A = 5.71 \text{ m}^2$$

$$p = 7.97 \text{ m}$$

(e) Rectangular Channel, $b = 25 \text{ ft}$,
 $Q = 1200 \text{ ft}^3/\text{sec}$, $n = 0.020$, $S_0 = 0.0004$

$$A = bz$$

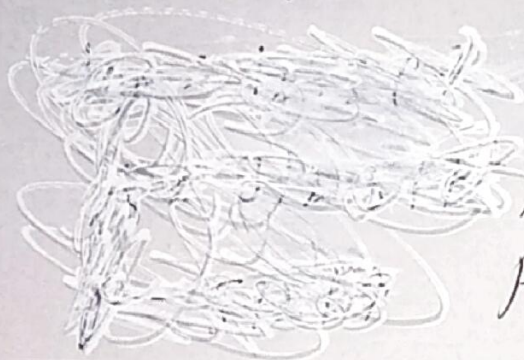
$$P = b + 2z$$

$$b = 2z \Rightarrow \cancel{b = 2z}$$

$$Q = \frac{1.49}{n} AR^{2/3} \sqrt{S_0}$$

$\downarrow$

$$805.3691 = AR^{2/3}$$



$$y_0 = 10.1565 \text{ ft}$$

$$A = 254.9135 \text{ ft}^2$$

$$P = 45.3931 \text{ ft}$$

$$y_0 = 10.20 \text{ ft}$$

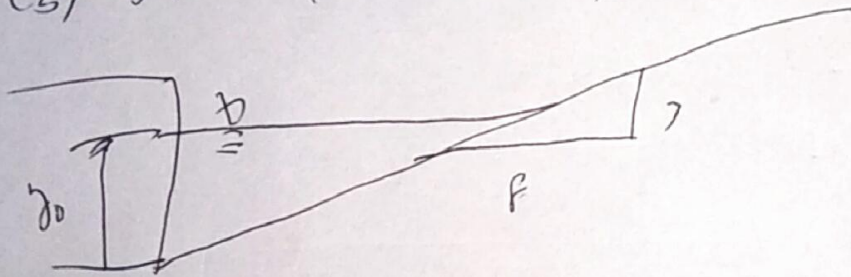
$$A = 254.91 \text{ ft}^2$$

$$P = 45.33 \text{ ft}$$

2.) (10 pts.) A channel cross section, commonly called a gutter, forms the side of a street next to a curb during rainfall conditions. The slope along the roadway is $S_0 = 0.0005$ and the Manning roughness coefficient is $n = 0.015$. Assume that uniform flow conditions occur:

(a) Determine the discharge if the depth of flow is $y_0 = 12 \text{ cm}$

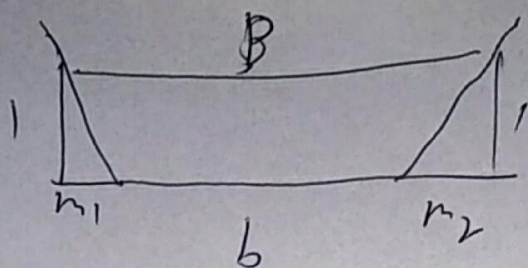
(b) If $Q = 80 \text{ L/s}$, what is flow depth y_0 ?



Solution

$$12 \text{ cm} = 0.12 \text{ m}$$

$$80 \text{ L/s} = 0.08 \text{ m}^3/\text{s}$$



$$y = y_0$$

$$A = by + \frac{1}{2} y^2 (m_1 + m_2)$$

$$P = b + y (\sqrt{1+m_1^2} + \sqrt{1+m_2^2})$$

$$P = b + y (m_1 + m_2)$$

For our problem:

$$A = (0)y + \frac{1}{2} y^2 (0 + 8) = 4y^2$$

$$P = (0) + y (\sqrt{1+0^2} + \sqrt{1+8^2})$$

$$P = 9.0623y$$

$$R = \frac{A}{P} = 0.4428y$$

$$Q = \frac{C_1}{n} A R^{2/3} \sqrt{S_0}$$

$$Q = 1.4507 A R^{2/3}$$

$$\frac{Q}{1.4507} = A R^{2/3}$$

(a) determine the discharge or the depth of flow

$$y_0 = 12 \text{ cm}$$

$$Q = 1.4907 (8 y_0^2) (0.8524 y_0)^{2/3}$$

$$Q = 0.009354 \text{ m}^3/\text{s} = 9.3540 \text{ l/s}$$

$$(a) Q = 9.35 \text{ l/s}$$

(b) if $Q = 80 \text{ l/s}$, what is the flow depth y_0 ?

$$0.08 = 1.4907 (8 y_0^2) (0.8524 y_0)^{2/3}$$

$$y_0 = 0.228461 \text{ m} = 22.8461 \text{ cm}$$

$$y_0 = 22.85 \text{ cm}$$